Defining an Integrated Energy Strategy for India

Ensuring security, sufficiency, and sustainability

teri

ISBN 81-7993-008-4

Published by
TERI
Darbari Seth Block
Habitat Place
Lodhi Road
New Delhi – 110 003
India

Telephone 2468 2100 or 2468 2111
E-mail mailbox@teri.res.in
Fax 2468 2144 or 2468 2145
Web site www.teriin.org
India +91 • Delhi (0)11

Printed at Friends colour image Pvt. Ltd, X-17, Hauz Khas, New Delhi – 110 016

Contents

Preamble

The need for defining an effective and comprehensive energy strategy for India is now an urgent imperative. Not only are there growing uncertainties about the stability and security within the global energy market but the expectations and aspirations of the Indian people for a much higher rate of growth also require a stable, low-cost, and secure supply of energy. It is difficult to arrive at precise estimates of the exact economic cost of unsatisfactory and unreliable supply of energy in the country. However, it is necessary to list the adverse effects of the present situation on the structure and mix of India's energy supply as well as the economic distortions that this is causing. Some of these adverse effects are as follows.

- Growth of essentially redundant and uneconomic, so-called 'captive power units' for generating electricity based on petroleum products
- Proliferation of voltage stabilizers and other devices to protect electrical equipment from voltage and frequency fluctuations
- Drop in production due to disruptions and outages in power supply.

Estimates of the cost to the economy for each kilowatt-hour of energy not supplied are in the range of Rs 15–25. Energy shortages, therefore, cause the Indian economy a huge loss apart from the adverse effects mentioned above. Rough estimates indicate that if the energy sector in India were to reach international levels of performance, the country's gross domestic product could go up by two per cent per annum. Another aspect, which past energy decisions have not dealt with, is the huge unserved population that relies essentially on collection of poor quality biomass fuels.

A forward-looking energy strategy must necessarily focus on this large population, which is deprived of the supply of modern energy forms and must be provided access to adequate, reliable, and environmentally clean energy sources. The benefit of creating appropriate solutions for rural areas would be the potential for increased incomes, which would accrue from energy options that can create employment opportunities and value addition to local produce.

Much attention has been provided to Reliance's discovery of natural gas in the Krishna-Godavari basin and the prospects of further reserves being found in the same area. Any new discovery of a significant size would certainly provide further energy security for India, but it is still essential to continue diplomatic efforts for import of natural gas through pipelines from our neighbourhood, including Iran, countries of central Asia, Bangladesh, and possibly Myanmar. Indeed, the recent find in the Krishna-Godavari basin would provide encouragement to potential investors for further exploration activity in this area. However, given the uncertainties attached to finding hydrocarbon reserves and the gestation period involved in setting up infrastructure and supply arrangements, gas imports should be kept clearly in focus. We are nowhere near a situation where we can ignore large-scale gas imports as a solution to our energy problems.

With the rapid increase in imports of oil, India also remains vulnerable to political developments that could take place in different parts of the world and impact on secure supply of crude oil. The developments in Iraq and the manner in which they unfold could have serious implications for oil supply globally. The growth of the hydrocarbon industry in Russia is

also of great relevance to India, particularly after the investments made in the Sakhalin oil field. Major geopolitical changes taking place in the former Soviet Union have major implications for India. For instance, some major international oil companies that had become active in Kazakhstan are now reported to be packing up and leaving, which could create a vacuum in that country. Can India possibly step in to fill up this gap and, if so, how can a supply line be established for hydrocarbons to be imported from that country?

Perhaps the least studied aspect of energy policy lies in respect of energy-related environmental implications. In 2005, negotiations will officially begin on the next commitment period under the United Nations Framework Convention on Climate Change and the Kyoto Protocol. Growing pressure on large developing countries like India, related to emissions of greenhouse gases, would require some actions that could have implications on energy choices to be made by this country. It is necessary to start evaluating these choices and assessing their economic, social, and technological implications in-depth, so that an enlightened strategy can be developed.

A major lesson to be learned in formulating India's energy strategy can be found in the experience of other countries that have successfully restructured their economic systems in cognisance of realities in the energy sector. Major energy-consuming sectors, like transport, have to become an important part of the energy strategy. In the case of India specifically, a major reversal of trends that have led to a shift in the share of rail transport to road transport has to be brought about vigorously. This can be facilitated only through the mobilization of resources for an efficient public transport system, particularly in urban areas and much greater use of rail transport for inter-urban transportation. Fiscal policies to make this happen would be major prerequisites for bringing about the desired shift.

An energy strategy has to be dynamic and flexible. Ideally, energy sector developments can be studied through the use of appropriate energy economy models, which would permit quantitative assessments of any change in driving forces based on realistic estimates from time to time. At present, India's policy is not served by the use of any specific model or set of

models. This situation requires change because only then can the choices be evaluated—for instance, choices resulting from the recent discovery of natural gas and prospects of further discoveries as well as changes in the supply of oil in the international market resulting from developments in Iraq. In essence, a far more enlightened and better-informed approach has to be pursued for defining and implementing India's energy strategy. This document, it is expected, would be a small step in that direction.

(R K Pachauri)
Director-General, TERI

India's energy strategy

Vision

To meet the energy needs of all segments of India's population in the most efficient and cost-effective manner promoting rapid economic growth while ensuring long-term sustainability

Provide clean and affordable energy to all

- Promote the design and establishment of decentralized energy service providers
- Design a basket of differentiated services available at differential prices to empower poorer customers to make a choice
- Re-assign energy subsidy allocations towards the provision of micro-credit

Ensure security of energy supply

- Map all energy resources and develop a databank of technology choices, efficiencies and costs to facilitate evaluation of trade-offs between alternative energy paths
- Facilitate investments in energy systems and efficiency improvements with the help of the private sector
- Encourage commercially-driven goal-oriented private and decentralized R&D (research and development) efforts
- Channel public R&D funds towards reducing cost of energy delivery to the poor
- Prepare energy plans to meet unforeseen emergency situations

Improve the efficiency of the energy system

- Open up energy markets to allow a larger number of players – public and private – in all market segments
- Adequately empower independent regulatory authorities
- Adopt uniform pricing principles, internalizing environmental costs, across all energy sub-sectors for meaningful competition and efficient resource allocation
- De-link the social function of subsidy provision from energy pricing decisions
- Institutionalize preparation of information systems, and communication and education programmes for promoting energy efficiency

Reduce the adverse environmental impacts of energy use

- Accelerate the development and market adoption of environmentally friendly technologies
- Strategically exploit opportunities arising out of international agreements such as climate change and the WTO (World Trade Organization) to meet energy goals
- Establish and enforce appropriate environmental standards.

Introduction

The energy sector in India is today administered at the apex level by the Ministry of Power, the Ministry of Petroleum and Natural Gas, the Ministry of Coal, the Ministry of Non-conventional Energy Sources, and the Department of Atomic Energy. Coordination and integration is achieved within the Government of India through the Cabinet and the Planning Commission. The respective ministries carry out coordination and integration with the state governments, with the National Development Council providing a forum for coordination at the highest levels of government. This structure has evolved over time but has also led to a vacuum as far as a coordinated vision and sustained action is concerned. It is only at the time of the formulation of Five-Year Plans that the sector is looked at as a whole. Even so, the Plan approach resembles more an aggregation of the plans of individual sub-sectors, rather than an integrated view of the entire sector.

While decentralization is certainly a process critical to success, the policy framework provided by the government has to be based on an integrated view and vision of the direction in which the energy sector should be moving, to ensure proper signals and incentives and a consistent legal framework are available to facilitate movement along the path of optimality.

The concept of an integrated energy strategy is not one that requires centralized action, but certainly involves a system and process of coordinated decision-making and actions that bring various energy activities and decisions into a common framework. Consequently, the institutional structure that allows integration of energy decision-making to become a reality would most appropriately rest on a system of integrated analysis, monitoring, and coordinated decision-making that becomes a regular part of policy formulation and implementation. There are four major elements of an integrated approach to strategy-making, which need to define the institutional structure adopted. First, the pricing of different forms of energy has to be carried out within an integrated framework. This involves addressing a host of issues such as tariffs, subsidies, and taxes within an integrated framework. Naturally, prices need to be determined by the market for reasons of efficiency, but in a poor developing country, equity and social concerns cannot be ignored. Nor can externalities such as environmental costs and impacts and issues of energy security be kept out of pricing decisions. Ideally, these should be under the preview of regulatory bodies that function on a coordinated basis within the framework of an integrated strategy so that consistency across the entire energy sector is maintained.

Second, another significant reason why integration of energy decisions becomes important is on account of the substitution possibilities between different forms of energy. Inter-fuel substitution would be determined, given time, by relative prices of fuels and different forms of energy. If, for social reasons, a particular mix of energy supply or consumption becomes desirable, then the policy framework for pricing should be consistent with such an objective. Movement towards a desirable mix of energy sources should, therefore, guide pricing decisions through regulatory frameworks and systems established for different forms of energy supply. This takes us to the third important element in defining integrated energy policies, namely consistent regulatory changes and structures applicable to different parts of the energy system. There is, for instance, not much point in regulatory reforms in the coal industry if this does not accompany similar reforms in the power industry. One can hardly create conditions for private sector investments in

coal production and supply unless it is accompanied, if not actually preceded, by similar reforms in the power supply industry to ensure proper payment for coal supplied. The lack of a uniform approach to regulation or deregulation for different parts of the energy sector can cause distortions or ineffective outcomes that do not promote efficiency or growth of the industry as a whole.

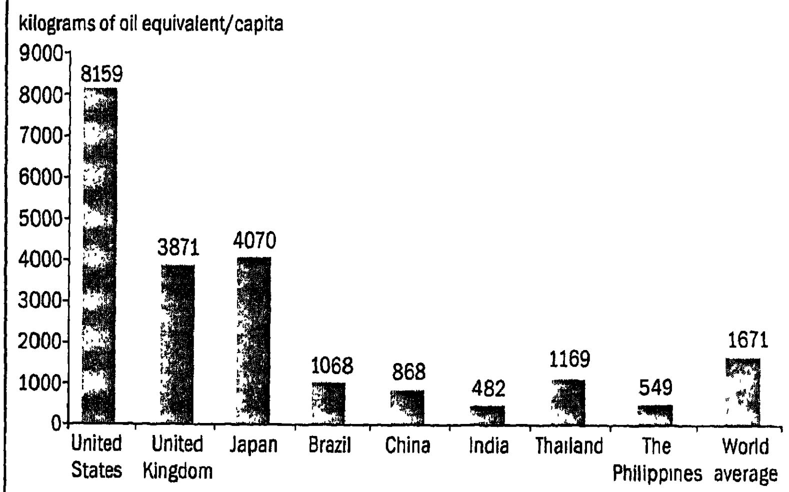
The final argument in favour of an integrated energy strategy relates to the role of technology. Even in the most liberal free market economy, research and development is funded to a significant degree by the government. For instance, the Clinton administration in the US had earmarked around 1.5 billion dollars for research on hybrid electrical vehicles in the automobile industry. The current administration, motivated undoubtedly by concerns related to energy security, is planning to provide substantial funds for development of fuel-cell vehicles. This would alter the mix of energy demand in that country substantially, based on technological change in the transport sector. Fiscal and regulatory measures become an important element in the development and deployment of technology once a direction or goal is established for strategic, social, or economic objectives. Technology is an important determinant of energy futures, and hence policy-making across all fuels and forms of energy must rest on an assessment of current and future technological options. Not only is an integrated approach missing, but the existing policy is still not all-encompassing in that it does not embrace the poor.

Energy: the steep road ahead

In the year 2011, India will have a total population of about 1.2 billion people of which 68% will be living in rural areas. Assuming an average GDP (gross domestic product) growth rate of seven per cent, the average annual per capita income would almost double to Rs 33 867. However, as is the case now, behind these averages would continue a significant disparity in incomes that would reflect a growing divide between the rich and the poor. As is evident now, the rich would be seeking bigger and better cars to be driven longer distances. On the other hand, meeting the basic needs of the poor – food, housing, education, and health – will continue to challenge the government. However, to drive all these developments and to reduce widespread poverty, one major input would be required – ENERGY.

Although India ranks sixth in total energy consumption in the world (294 MTOE [million tonnes of oil equivalent]), this is only 12% of the energy consumed by the largest consumer, i.e. USA (2278 MTOE). In per capita terms, its consumption is only about 20% of the global average (Figure 1). With India targeting ambitious growth rates of seven to eight per cent over the next two decades, its per capita energy consumption must necessarily rise in the future.

Figure 1 Comparison of per capita energy consumption of countries (1999



Source The World Bank (2002)

On the supply side, indigenous production of commercial energy in India increased from 74 MTOE in 1980/81 to about 196 MTOE in 1999/2000, registering an average rate of growth of about 5.3% per annum. The energy supply profile has been primarily dominated by coal. However, the share of oil and gas in the country's primary energy production has been rising rapidly; it increased from 17% in 1970/71 to about 28% in 1999/2000.

Current coal reserves aggregate 221 BT (billion tonnes) out of which proven reserves stand at 84 BT. However, on account of production constraints, coal availability is likely to be well below demand in the foreseeable future. The Working Group on Coal and Lignite for the Tenth Five-Year Plan estimates that as against a demand of 453 MT (million tonnes) by 2006/07, supply would be only 400 MT. The situation worsens by the end of the Eleventh Plan with demand going up to 620 MT as against availability at 515 MT. In fact, recent analysis undertaken by the Central Mine Planning and Design Institute suggests that current coal reserves may only last another 45–50 years (See Box 1) as against earlier expectations of reserves lasting for more than 200 years.

Box 1 Banking on coal :: fuelling insecurity

Coal, until recently, was considered the major commercial energy resource of the country to last for over 200 years. However, recent estimates of mineable/extractable reserves of CIL (Coal India Ltd) present a new scenario in stark contrast to the former one.

Out of the total geological resources of 220.98 BT (billion tonnes) up to a depth of 1200 m, only 84.41 BT is of proved variety. Applying the mineable/extractable criteria, the total resources translate to less than 40 BT of extractable reserves.

Based on past experience and geological reports available with the Central Mine Planning and Design Institute, it has been estimated that for every 1 MT (million tonnes) of mining capacity, 140 MT of reserves are required to be established in ground through detailed exploration (at 85% capacity utilization) or in effect an annual reserves-to-production ratio of 4.7:1 (for coal resources in the depth range of 0–300 m).

If the demand for coal is estimated to be 0.5 BT by 2006/07, 0.6 BT by 2011/12, and 0.77 BT by 2016/17 and assuming the demand to plateau thereafter, coal resources can at best be expected to last for another 45–50 years only (CMPDI 2001).

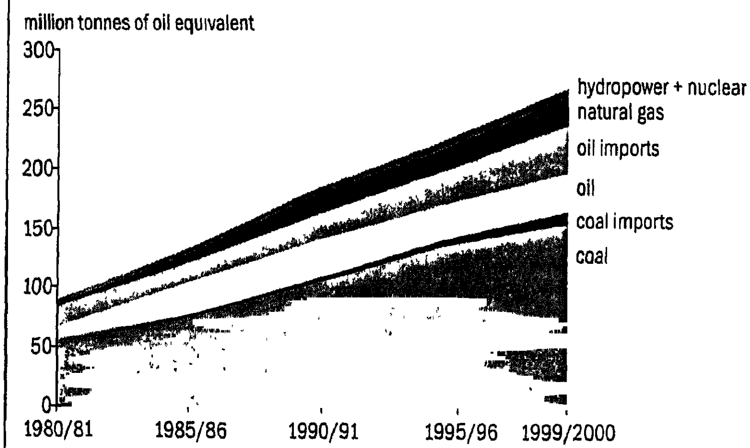
The finitude of coal resources could have a significant bearing on the country's energy security, considering that coal is the dominant energy source for the economy.

Figure 2 brings out an already increasing reliance on imports for meeting the demand for coal and oil. The situation is more serious in the case of oil. The only major shift in country's oil import pattern that has taken place, as a result of encouraging private participation in refining activities in the last decade, is reduction in imports of petroleum products. Crude oil imports, today, however, account for over 70% of consumption.

As per current projections, India's oil import dependence is expected to increase and, since most of this is from the Middle East, there are serious concerns about energy security. The Working Group on Refining for the Tenth Plan estimates that India's crude oil requirement is expected to increase to 177 MT by the year 2006/07. In contrast, domestic crude oil production by the end of the Tenth Plan would only be 32 MT, necessitating crude imports on the order of 145 MT.

Natural gas production, too, is limited and demand is outpacing supply. Several efforts are under way to explore the

Figure 2 India's primary energy supply



Source Compiled from various editions of *TERI Energy Data Directory & Yearbook*

possibility of importing natural gas either in the form of LNG (liquefied natural gas) or as piped natural gas through the eastern as well as the western border of India, prospects for which seem remote at the moment. The recent find of gas reserves in the Krishna-Godavari basin, however, may ease the pressure somewhat. Simultaneously, the potential for exploiting CBM (coal-bed methane) is also being explored.

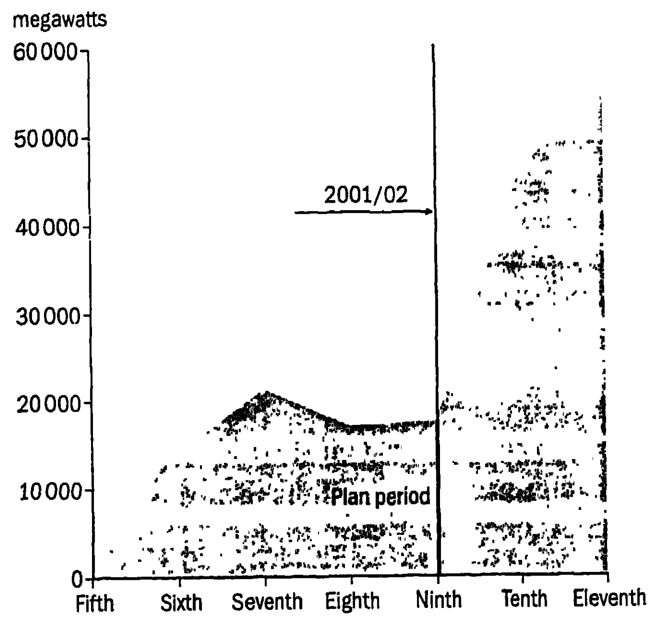
The electricity sector has also been experiencing severe shortages for almost two decades now. In 2000/01, all-India energy shortages stood at 7.8% while peak shortages were 13% (CEA 2001). The more critical number here is the extent of peak shortages. Table 1 presents the current regional position with respect to peak shortages. As is evident from the data, shortages are prevalent in all regions. It has been projected that electricity demand would grow at approximately six per cent per annum over the period 1997–2012. The magnitude of the challenge in meeting this demand is brought out in Figure 3, which compares the capacity additions that would be needed in this period to meet supply targets with actual capacity achievements achieved in the last four Plan periods.

Table 1 Peak power shortages in India (%), June 2002

Region	*Peak Shortage*
Northern region	−7.9
Western region	−23.0
Southern region	−15.6
Eastern region	−4.9
North-eastern region	−7.5
All India	−14.5

Source CEA (2002)

Figure 3 Electricity capacity additions: past and projected



Source Compiled from various Plan documents

Apart from commercial energy forms, India has substantial renewable energy potential (Table 2). However, a large part of this potential still remains unexploited.

In sum, the gap between energy demand and domestic production is likely to widen if the present trends continue, leading

Table 2 Renewable energy potential in India

Source/systems	Approximate potential[1]	Energy substitutions potential[2]	[illegible]
Biogas plants (units)	12 million	19 MT of fuelwood	3.2 million
Improved cook stoves (units)	120 million	48 MT of fuelwood	33.8 million
Biomass energy	19 500 MW	60 MT of coal	358 MW
Wind energy	45 000 MW	55 MT of coal	1507 MW
Small hydropower	15 000 MW	36 MT of coal	1423 MW
Solar energy	35 000 MW/ '000' km^2	38 MT of coal	

MT – million tonnes, MW – megawatts

Sources [1] MNES (2001); [2] TERI estimates

to a growing dependence on energy imports even in the short term (Table 3).

However, the scenario given in Table 3 is under the assumption of business as usual and can change with proactive governmental policy and technological intervention.

Table 3 Energy demand–supply gap: 2006/07 and 2046/47

Fuel	2006/07[1]			2046/47[2]		
	Demand	Imports	Import dependence	Demand	Imports	Import dependence
Oil (MT)	129	94	73%	702	622	88%
Coal (MT)	453	54	12%	1553	953	61%
Natural gas (MMCMD)	180	81	45%	550	513*	93%

MT – million tonnes, MMCMD – million metric cubic metres per day
* Excludes probable new sources of indigenous supply

Source [1] Various working group reports for Tenth Plan; [2] Pachauri and Batra (2001)

A sustainable path

The demand for energy is derived from the demand for other goods and services, since it is the service that energy provides in production and consumption that determines the type and magnitude of energy demand. Hence, an integrated energy strategy would not treat demand as inflexible in the future, which needs to be met under any circumstances. In fact, an enlightened energy strategy, which uses resources optimally, would cover actions and initiatives on both demand as well as supply. It is often less expensive, for instance, to bring about technological changes or, even better, housekeeping measures to reduce demand than to add equivalent capacity for enhancing supply. Further, in maintaining a balance and serving national interest, the energy strategy would need to serve the objectives of equity, security, efficiency, and environmental protection.

Equity

The alleviation of poverty is a major challenge for the society and also for policy-makers at all levels. Energy policies in the past have not paid adequate attention to the plight of the poor.

It is, therefore, essential to ensure that meeting the needs of the poor is merged into the mainstream of energy policy, with the ultimate objective of enhancing opportunities for sustainable livelihoods. Provision of good quality and adequate energy is central to the objective of removing poverty, in the absence of which society would suffer from serious disorder and dysfunctional conditions.

In the context of energy consumption, considerations of equity would have several dimensions. The most important of these is to ensure that adequate energy of good quality is available and accessible to all, such that the poor are able to meet their needs, particularly of cooking fuel and basic lighting. The aspect of quality is important because the use of biomass fuels with low calorific value has serious health implications on account of resultant high levels of indoor air pollution. Clean and good quality fuels, therefore, need to replace the large-scale use of inferior fuels currently prevalent in India.

Globally, about two billion people do not have access to modern energy carriers, such as electricity, and non-traditional cooking fuels like LPG (liquefied petroleum gas); they rely instead on wood, dung, and other biomass. It is estimated that of these two billion people, around 700 million live in India (The World Bank 2001). The only effective means to lift this deprived section of society out of their current crisis is to ensure that even if financial support is initially provided to them in some measure to purchase and use clean and good quality fuels, over a period of time they must be able to enhance their incomes to afford these fuels through normal market transactions. In this context, energy has to be seen as part of an overall development strategy. Interventions in the energy sector would provide only short-term benefits unless they are combined with matching interventions in other sectors, which lead to the spread of economic opportunities among the poor.

With increases in income, the demand for energy evolves from basic energy end uses, such as cooking and lighting, to mobility, space conditioning, and entertainment, all of which need larger quantities and different forms of energy. It is now apparent that keeping specific technologies out of the reach of the poor restricts their abilities and opportunities for economic development. Strategies for meeting the needs of the poor and

ensuring their progression to wider and higher forms of energy uses would be well served by policies that make modern technology available to them, even at low income levels. For instance, solar lanterns using photovoltaic technology are as compatible with the ability and need of the poorest of the poor to use them appropriately as they would be among more prosperous sections of society.

Security

There are several aspects of energy security that need to be incorporated into an integrated energy strategy. However, recent experience has shown that while physical restrictions in supply may not be a serious threat, it is the economic impact of fluctuating oil prices that is perhaps the most serious issue for consideration in the security of energy supply. Energy security needs to be enhanced through specific short- as well as long-term measures. In the short term, when technologies and capital assets cannot be changed substantially, ensuring energy security would involve means by which efficiency of energy use is achieved through short term measures, such as better housekeeping in industrial units, better maintenance and upkeep of transport vehicles, improved traffic management, and various other ways by which wastage of energy is minimized. At the same time, adequate storage of energy, particularly oil and oil products, on which India's import dependence is predominant, would become an important supply-side option. The long-term challenge of energy security, however, lies essentially in a series of measures related to securing the supply of hydrocarbons as well as in bringing about a diversity in the use of energy as also its sourcing. This would involve conscious decisions often for restructuring the very nature and mix of economic activities in a country. The development of newer energy forms such as CBM and gas hydrates also present long-term options that need to be exploited.

Efficiency

In its broadest sense, energy efficiency would encompass all measures that would bring about efficient use of energy re-

sources leading to a reduction in the need to produce energy. This would include production, conversion, transmission/ transportation, and consumption efficiencies as well as any measures that can be put in place to reduce the level of demand itself—peak or otherwise. In this sense, energy efficiency measures should not only enhance energy security by spreading available energy resources over a longer period of time but also mitigate environmental impacts and reduce the cost of energy delivery.

Environment

The environment, as any other factor of production, can become a non-renewable resource if exploited beyond a sustainable level. In recognition of the limits that environmental degradation places on economic growth, the United Nations too has been advocating the development of natural resource accounts that would enable a country to account for a depletion of its environmental and natural resource wealth.

The process of producing, transporting, and consuming energy has a significant impact on the environment at all stages. While we are yet to internalize the costs of environmental depletion in a systematic manner, several studies have captured the adverse impact of energy use on the environment. Some of the commonly known environmental impacts of the energy cycle include air pollution, land degradation, and deforestation.

Environmental impacts of energy use once again vary with the level and pattern of economic development. The environmental impacts of biomass energy are manifested in the depletion of the very resources on which the poor are dependent and in the adverse impacts of indoor air pollution on health, particularly of the vulnerable section within the poor—women and children. As energy needs increase beyond subsistence applications, environmental problems manifest themselves increasingly in the form of rising levels of ambient air pollution leading to environmental health problems at a local level; acid rain at the regional level; and climate change at the global level.

It is interesting to note here that the perceived relative importance of different air pollution problems changes from indoor to local to global as income levels increase from low to

Figure 4 Stylized depiction of relative sensitivity* of income groups to air pollution from energy use

Income category	Indoor	Ambient	Stratospheric
Low income			
Middle income			
High income			

*in terms of vulnerability, time scale of impact, and ability to cope

Very high ■ Medium ▯ Low

high (Figure 4). However, it needs to be recognized that transboundary and global environmental effects can greatly influence the energy and technology choices of all countries, developed and developing.

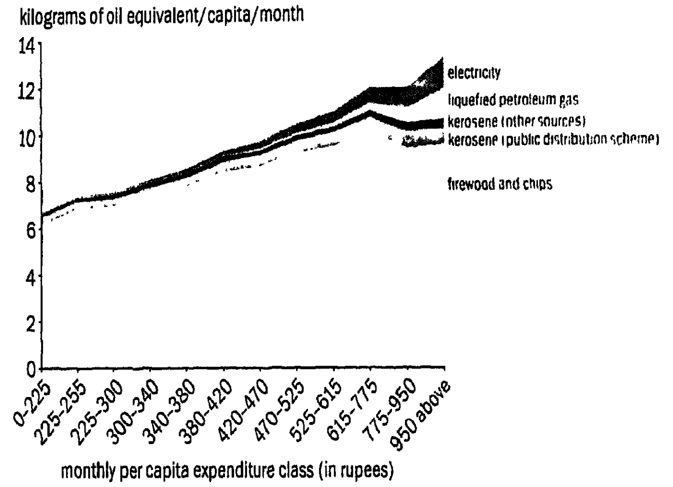
Trudging an arduous path: the experience

The key to the energy challenge will be to ensure adequate availability of energy for all, delivered in the most cost-effective manner without compromising either on the long-term interests of the country or on the quality of our environment. In this section, we discuss the issues facing the energy sector, the coping strategy historically adopted by the government to supply energy, as well as some of the more recent measures that have been put in place to deal with increasingly unsatisfied energy needs. For purposes of continuity, these issues are discussed under the same heads as defined necessary for a sustainable energy future. In reading this section, it needs to be borne in mind that since the early 1970s, and till recently, the government has been primarily responsible not only for policy-making but also for the regulation and supply of energy.

Providing energy to all

Recognizing the need to provide access to energy for the poor, various governments in the country have provided subsidized energy either through the PDS (public distribution scheme) or

Figure 5 Gross energy consumption: rural, by expenditure class



Source NSSO (2001a)

though the SEBs (state electricity boards). Typically, these have involved complex cross-subsidy schemes to ensure availability of LPG and kerosene to domestic consumers at subsidized prices through the PDS and subsidized electricity to the residential and agricultural sectors by the SEBs. In the case of agriculture, the government embarked on a major programme of rural electrification, driven largely by food security considerations.

Despite these measures, a large number of poor in India still do not have access to commercial energy forms (Figure 5). While 86% of the villages in the country have been electrified, only 48% of the households actually use electricity for lighting (NSSO 2001b). The subsidies for residential fuels have not been well targeted and the actual beneficiary groups, more often than not, do not merit receiving subsidies. There is also large-scale diversion of subsidized kerosene for adulteration with diesel (Planning Commission 2000).

A large portion of the rural population continues to depend on biomass fuels. As a result, the demand for fuelwood continues to be high, far above sustainable production levels. While attempts have been made towards bridging this gap through both demand- and supply-side measures, the lack of

Box 2 **Fuelwood conservation**

Fuelwood conservation programmes like the National Programme on Biogas Development and the National Programme on Improved Chulhas are technology-driven programmes with fixed annual targets and budgetary allocations based on targets achieved. Similarly, large afforestation programmes are focused on nursery raising and planting with annual targets of area covered (public and forest lands); seedling distribution for planting, production, and distribution of quality seeds; etc. Due to the lack of a concerted approach, the effectiveness of afforestation programmes to augment the availability of biomass has been limited, since fuelwood conservation programmes do not supplement these.

coordination amongst afforestation programmes and meeting rural energy needs reduces the effectiveness of both sets of these activities (Box 2).

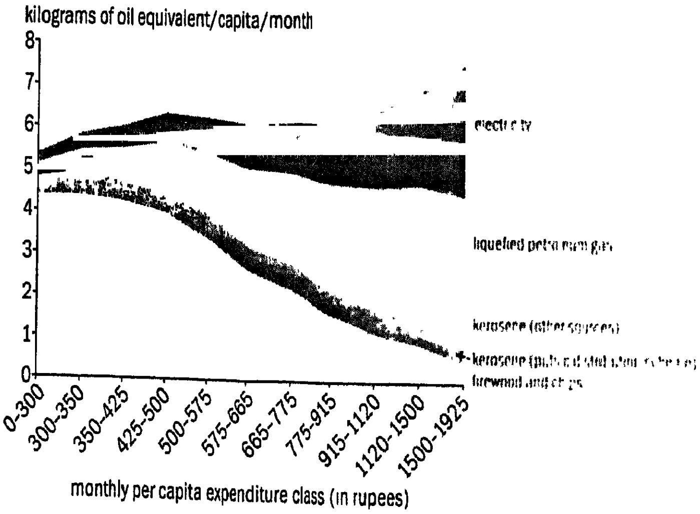
By their very nature, rural areas are amenable to the use of renewable energy. The cost of extending grid connections to sparsely populated and dispersed villages is exorbitant. On the other hand, RETs (renewable energy technologies) generally provide decentralized and modular ways of meeting energy demands of these areas. Rural areas in India have an abundance of solar energy that can be exploited for both thermal and electrical applications. Biomass energy is conventionally referred to as traditional energy but, when used in modern technology applications, also qualifies as renewable energy.

The rural fuel mix, therefore, extends across a broad spectrum of options—commercial fossil fuels, traditional biomass resources, and RETs. Sectoral programmes adopted for any of these options can really be effective if they are implemented in a coordinated manner to complement each other. The challenge is to design policies and mechanisms by which clean and better quality energy can be accessed by the poor.

Urban areas, too, are plagued with issues of basic accessibility to energy. Without affordable access to subsidized fuels, 22% of the urban population continues to rely on traditional fuels (NSSO 2001b).

On the other hand while the urban non-poor do have access to commercial energy forms (Figure 6), the quality suffers due to the huge demand–supply gaps and irrational pricing structures. A case in point is the price differential between kerosene and

Figure 6 Energy consumption: urban, by expenditure class



Source NSSO (2001a)

diesel, which resulted in diversion of the subsidized kerosene to adulterate diesel thereby not only depriving the targeted population from access to subsidized fuel but also creating higher pollution levels. Electricity black-outs and brown-outs have ensured the proliferation of diesel generators, voltage stabilizers, and inverters in urban non-poor households increasing their expenditure burden for meeting demands. If this additional expenditure undertaken by the non-poor is internalized into their tariffs, the effective cross-subsidy from the non-poor to the poor would be substantially higher than reflected in the tariff structures.

Energy security

Import and export of energy have important implications for energy security and the government, therefore, closely regulates both. Energy security requires that we minimize our dependence on imports. Where inevitable, imports should be regulated so that least-cost options are used to provide energy for the requirements of economic growth and welfare. Box 3 provides an illustration of one such trade-off that needs to be examined.

Box 3 Importing fuel for power generation: LNG or coal?

A comparison between the two fuels has both spatial and temporal dimensions. For a location like Hazira, the levelized cost of generation of power using this gas would be Rs 2.10 per unit and that from imported coal would be Rs 2.38 per unit. The underlying assumptions are as follows.

- At a crude oil price of $22/barrel, LNG (liquefied natural gas) from the Persian Gulf should cost $4/MMBtu (million metric British thermal units) after regasification.
- A price of $40/MT (million tonnes) for coal, which is the long-term average price of coal

If the cif (cost, insurance, and freight) price of coal drops to $30/MT, the cost of generation would decrease to Rs 2.17 per unit.

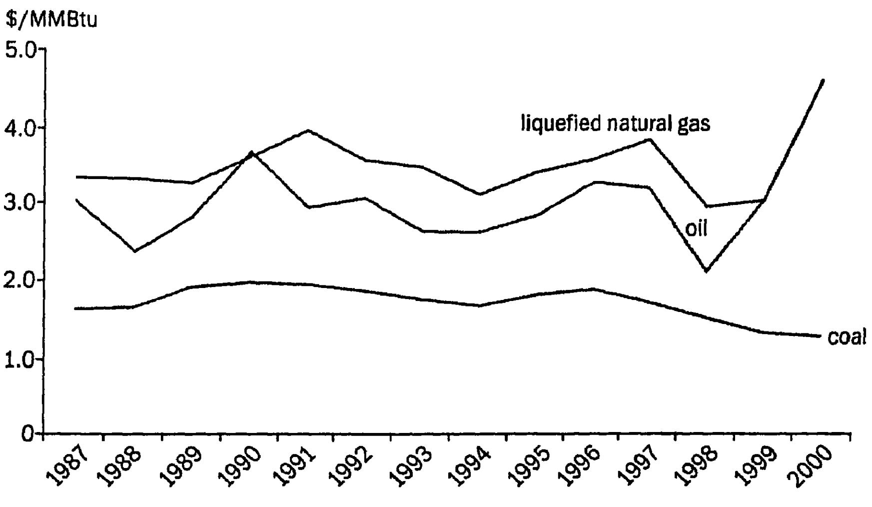
If the gas is put into the HBJ (Hazira–Bijapur–Jagdishpur) pipeline, it could reach up to Delhi at the current transportation cost of $1/MMBtu. Compared to this, the cost of moving imported coal by railway at the current freight charges is $0.65/MMBtu for large distances and more for shorter ones. Nevertheless, the cost of generation using gas would be cheaper along the HBJ pipeline. However, there are two factors that could take away this advantage from gas.

- If the rail freight charge for coal is modified so that coal freight does not subsidize other freight movement by the railways.
- If a gas pipeline has to be laid afresh, the gas transport cost could be much higher depending on the volume.

Under the above conditions, coal may turn out to be a cheaper option.

The comparison becomes complicated when we take the time factor into account. LNG prices are indexed to crude oil prices whereas the price of coal moves independently. The figure below shows that coal prices are more stable than oil prices.

Since the use of LNG involves signing a long-term contract for 15–20 years, it would be necessary to have a price ceiling to make it competitive with imported coal over the long term.



Source TERI analysis

Import dependence needs to be particularly curbed for oil, which has a volatile market and is prone to supply disruptions. Quantitative restrictions were often the instrument used to regulate imports and exports. For instance, in India, imports of crude oil were canalized through a public sector company - the Indian Oil Corporation – till recently. However, in an era of globalization overseen by the WTO, whether trade interventions in the energy sector would continue remains to be seen. Therefore, the potential for diversity in energy imports and sources must be looked at.

The SAARC (South Asian Association for Regional Cooperation) region itself provides several alternatives for diversifying imports. Gas imports can take place from Bangladesh (about 14 MMCMD [million metric cubic metres per day]) and through Pakistan (Iran–Pakistan–India pipeline for importing 50–75 MMCMD of gas) provided that economics takes precedence over politics. The gas import potential from Myanmar is in the range of 17 MMCMD (Hydrocarbon Asia 2001). Likewise regional exchanges in power are also possible given the large potential for hydropower generation within the region. Nepal has a total hydropower potential of 80 000 MW and Bhutan has a potential of about 35 000 MW of which their current consumption is less than one per cent. India could tap into this huge regional resource, provided, of course, that we are able to address the associated human and environmental impacts.

Since India's major energy imports are in the form of crude oil, the specific issues relating to oil need special mention. The choices available to increase oil security include the following.

- Establishment of a strategic oil reserve
- Diversification of sources of oil imports
- Investment in equity oil abroad
- Enhancement of domestic supply.

India, thus far, had not put in place adequate strategic reserves. Only operational reserve requirements of 30 days are specified. As far as diversification and investments in equity oil are concerned, the market may prove inadequate and aggressive policy initiatives will be called for. The management of supply disruptions and stabilization of the oil price require regional and international cooperation between consuming countries as well as a dialogue between oil producers and consumers.

Such cooperation is also required in South Asia. As mentioned earlier, the hydropower option from Nepal and Bhutan and gas from Myanmar and Bangladesh are logical solutions, implementation of which requires sustained diplomatic efforts towards regional cooperation and integration of energy markets. Besides, for import of gas from Iran, a secure and mutually beneficial arrangement with Pakistan would be essential. However, the need for gas imports – LNG or piped gas – will need a fresh evaluation in light of the recently discovered gas in the Krishna-Godavari basin.

Given the energy scenario in rural India, the energy security strategies here may require a special and disparate focus. There emerges a pressing need for a strategy that sets a detailed framework for planning, implementation, and follow-up of coordinated initiatives to deliver affordable and reliable energy options to the masses, combined with other aspects of development. Renewable energy sources assume special significance here too given the geographic diversity, size of the country, and the widespread endowment of renewable energy resources. The major application areas of RETs can be categorized in the following manner.

- Minimum rural energy needs
- Decentralized energy supply for agriculture, industry, commercial, and household sectors in rural and urban areas
- Grid-quality power generation and supply.

From the point of view of long-term security concerns, options such as nuclear and hydropower gain significance for a country like India. The nuclear power capacity in the country currently is 2720 MW. India is targeting for 20 000 MW of capacity by 2020. Such large-scale capacity addition may prove to be difficult considering the lumpy investments that would be required, especially in the current context where the programme is driven primarily by budgetary support. Long gestation periods further compound the problem. In addition, their remains ambiguity with respect to costs of waste disposal, though some trade-offs can be envisaged with possibilities of reprocessing waste for subsequent stages. Further, amidst growing concerns on proliferation, the success of the 2020 vision is contingent upon import of technology (specifically for Light Water Reactors). While addressing genuine proliferation concerns, India would

have to lobby hard to seek a new nuclear world order wherein the extent of technology controls is substantially reduced.

Budgetary constraints have also affected hydropower development. The experience thus far with getting the private sector interested in hydropower development has not been very encouraging. Further capacity addition would necessitate urgently involving the private sector. Given the large upfront investments and relatively larger project risks, the government may need to devise special mechanisms by which to attract the private sector. In this context, the Centre and the states must also explore avenues for reduced gestation periods, effective rehabilitation measures, etc.

The question is do we have the institutional structures that can bring about such an integrated outlook? If gas imports are handled by the Ministry of Petroleum and Natural Gas and power imports by the Ministry of Power, who is responsible for evaluating their relative economics and merits? If the Ministry of Finance uses duties only to raise revenues based on demand elasticities and the Ministry of Railways use the freights to balance its budget, who evaluates these in the context of energy security? These are the questions that the people of India and their elected policy-makers need to address.

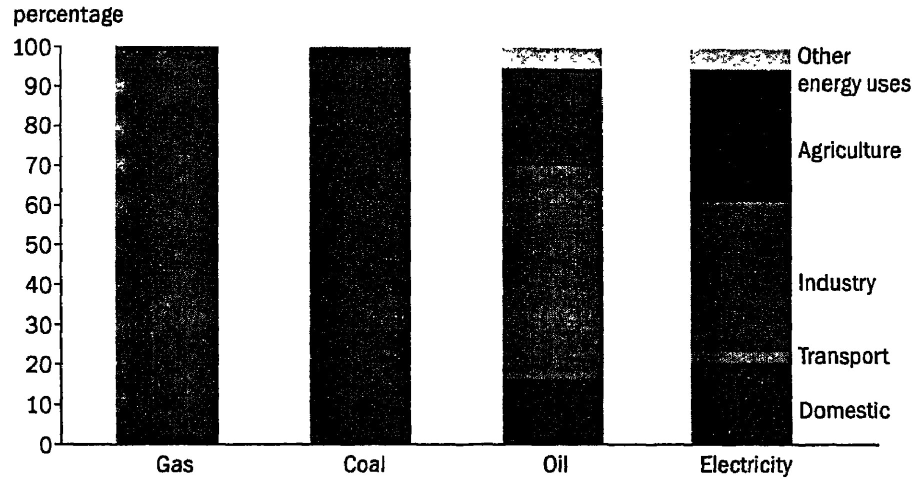
Energy efficiency

Figure 7 provides an overview of the relative importance of different energy forms in meeting the energy needs of various sectors.

The industrial sector accounted for about 56.9% (including feedstock) of the total commercial energy used in the country in 1999/2000. The estimated energy conservation potential in selected industries is highlighted in Table 4. Electric motors, which account for 70% of all industrial energy use, have a potential savings of 20%–25% through efficiency measures.

The share of electric lighting is about 13% of the total electricity consumption in all the sectors, with a share of 9% in the industrial sector. A World Bank study (1991) estimates that by the year 2005, the total lighting consumption load by all types of consumers would be 65.5 billion units, representing more than 30 000 MW of supply. The saving potential at this level of

Figure 7 Final energy consumption pattern, 1999/2000



Source TERI (2000)

Note Excludes consumption in the transformation sector like power

Table 4 Energy savings potential in selected industries/sectors

Industry	India (Gcal/tonne)	World (Gcal/tonne)
Aluminium	14.55	12.35
Steel	8.00–9.55	4.00
Cement	1.00	0.80

Gcal – gigacalories

Source GoI (1997)

lighting is 9600 MW at end-use if efficient appliances are used. Fiscal measures must, therefore, target and provide incentives for efficient lighting systems.

Electricity is a major energy form used in the commercial sector in India, of which approximately 60% is consumed in lighting and 32% in space conditioning. Energy audit studies conducted in several hotels, hospitals, and office buildings reveal significant techno-economic potential of energy saving in different activities. These are summarized in Table 5. TERI has

Table 5 Commercial sector potential savings (%) estimates

End uses	*Technical potential savings estimate (%)*
Lighting	20–50
Cooling	≥15 without efficient lighting measures; 80 with efficient lighting measures; average is 30
Ventilation	50
Heating	15–40
Refrigeration	15–40
Water heating	40–60
Miscellaneous	10–30

Source Various energy audit documents

Box 4 RETREAT: TERI's executive training facility, Gual Pahari, Gurgaon

Located about 35 km south of Delhi, as a model of sustainable habitat based on new and clean technologies, TERI's field office houses the RETREAT, a 30-bed training hostel with conference and ancillary facilities. It has been designed on principles of sustainable architecture and is fully energized by renewable energy.

The salient design features of the building complex are as follows.

- Building insulation for reducing space conditioning loads
- Part of the building sunken into the ground to take advantage of ground storage and thus stabilize internal temperature
- Shading devices and fenestration designed to cut off summer sun and to let in winter sun
- Glare-free daylight for conference hall, library, and recreation hall through use of specially designed skylights
- Landscaping to favourably alter wind directions
- Space conditioning of the residential block through a network of underground earth air tunnels
- A solar chimney with a flat plate collector on top to create a draught and exit for hot air on the south-facing rooms
- Cooling of conference block by an energy-efficient, environment-friendly ammonia-based absorption cooling system
- Use of energy-efficient lighting techniques
- Solar water heating system to meet hot water requirements
- Hybrid system based on biomass gasifier and solar photovoltaic, with a battery bank and an intelligent load manager to meet energy requirement of the building
- Wastewater recycling through the root zone technique; the treated water is used for irrigation.

The initial cost of the building, with the energy-efficient and renewable energy devices, is about 24% higher than a conventional building of similar size and function. However, the annual saving in energy costs is over 50% as compared to the energy costs in the conventional building.

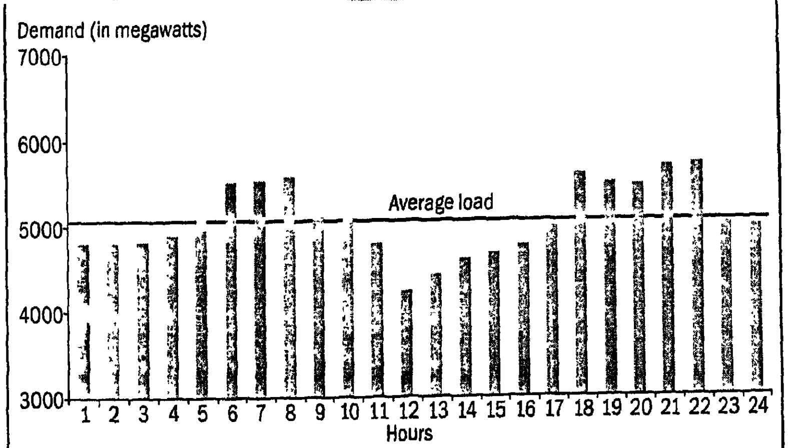
also demonstrated the concept of sustainable habitats that combine passive building design characteristics with energy-efficient and renewable energy devices to significantly reduce a building's energy load (Box 4).

In the domestic sector, lighting accounts for 35% and space conditioning for 30% of the total electricity consumed in the sector. Approximately 13% of the electricity consumed is in refrigerators and 8% in water heating. The energy efficiency improvements possible in this sector are in the range of 20%–30%.

In agriculture, out of nearly 20 million pump sets in India, about 60% is driven by electric motors and the rest by diesel engines. Motors used by the farmers are generally of poor quality and efficiency. The initial high cost of energy-efficient motors, the flat rate tariff structure, and lack of knowledge about the long-term gains are the major factors responsible for this. A pilot study conducted by TERI (1996) estimates the saving potential in the range of 30%–35% through major and minor retrofitting measures.

Load shifting from peak to off-peak periods can reduce peak power demand. Figure 8 illustrates the typical load pattern experienced by a state-owned utility in the northern region. Given that peaking demand in India is primarily met through hydro-based generation, the impact of load shifting would be

Figure 8 Typical daily electricity load curve



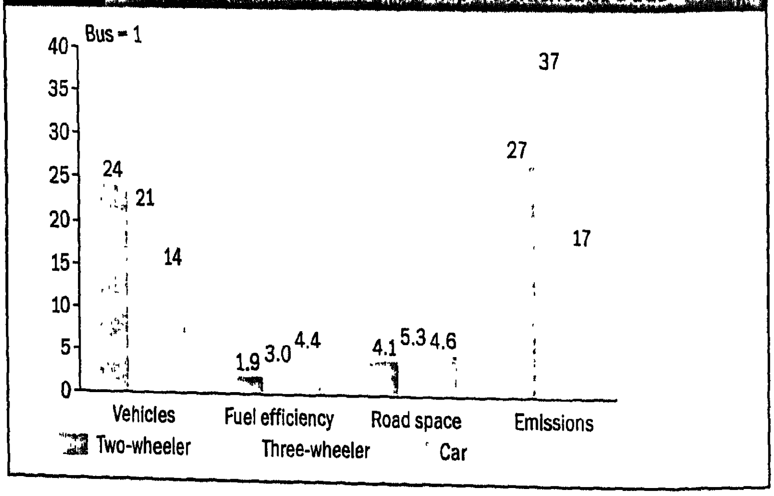
(Load curve data: Uttar Pradesh State Electricity Board, 20 January 1998)

more pronounced on investments required in T&D (transmission and distribution) to meet peak loads. Time-of-use tariffs, with a substantial difference between peak and off-peak tariffs (reflecting the incremental costs in T&D), can bring about a significant shift in loads. Such practices are being followed in the telecommunications sector in India with success.

Commercial energy consumption in the transport sector grew at a rate of 4.9% per annum in the 1980s and 5.4% per annum during the 1990s. A shift from railways to road, inadequate exploitation of modes like coastal shipping and inland water transport for freight movement, and inadequacies in the public transportation system leading to an increase in the use of personalized mode of transport have all contributed to the higher rate of growth in energy consumption. If the current trends in travel demand continue, the modal split will become increasingly skewed in favour of road with worsening impacts on the environment and the economy. Figure 9 provides a comparison of alternative modes of transport on different parameters.

On the positive side, liberalization of the licensing scheme in the early 1990s as also regulations such as the introduction of the Bharat Stage 2 norms relating to environmental performance have resulted in the introduction of a number of fuel-efficient vehicles in the cars segment. The improvement in fuel efficiency is, however, limited largely to personal vehicles

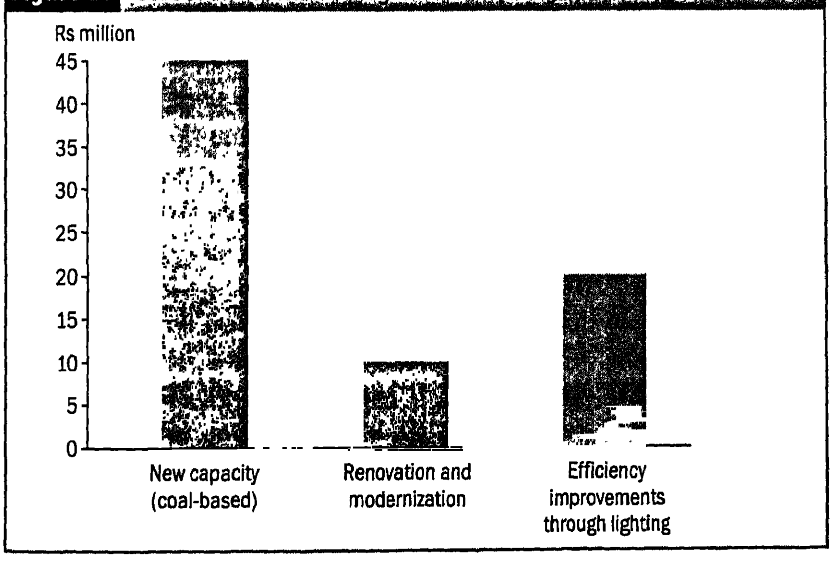
Figure 9 Alternative modes of transport indexed to a bus



because this development has largely been an ad hoc response to judicial interventions on environmental considerations and not part of a well-planned strategy for reducing energy use in the transport sector. It is well recognized that current vehicle technologies in India are inferior to those in the developed world. For instance, the largest segment of the vehicular fleet, namely two-wheelers, mostly uses the highly inefficient two-stroke engine. Freight operators in India are known to overload their trucks by 40% leading to higher energy consumption and greater damage to the road surface (AITD 2000).

On the supply side also, there exists a vast potential for energy savings. The average thermal efficiency of a power plant in India is about 29% whereas efficiencies of 35%–42% are now achievable. Given that availability of financial resources is a constraint, India needs to make a judicious choice of how to distribute its scarce financial resources across new capacity, capacity enhancement through R&M (renovation and modernization), and/or capacity saving through efficiency improvements. Figure 10 presents the relative costs of an additional megawatt through these various options. The importance of R&M measures was recognized in the past too. However, the lack of a coordinated approach combined with a system of performance measurement that only recognized capacity addi-

Figure 10 Cost of an additional megawatt of capacity from alternative methods

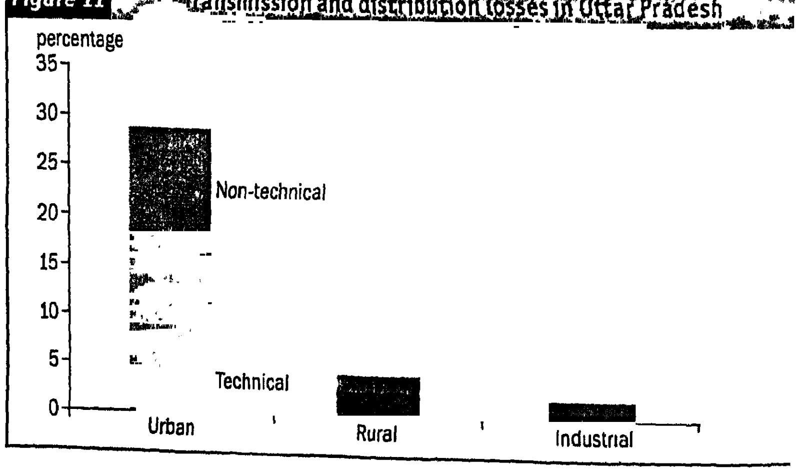


tions resulted in a diversion of these resources to capacity creation. The figure corresponding to efficiency improvement is based on efficiency improvements in lighting. The added attraction of this approach would be that investments in efficiencies would be made by consumers if the right pricing signals were in place.

The reforming states of the country have shown that actual T&D losses are in the range of 35%–50% and not 22%–23% as shown by official statistics. Contrary to popular belief, a significant contribution to losses (in other words, theft) is made by urban and industrial consumers, as brought out by Figure 11.

Most energy sub-sectors were historically under an administered pricing regime that was based on covering the cost of supply plus a specified rate of return to producers. Retail pricing, however, more often than not, seemed to be independent of the cost of supply and was guided by political considerations, such as the ostensible need to subsidize the poor. The issue of subsidies has been discussed in relation to the provision of energy for all. The cost of subsidies was largely met through the design of a complex system of cross-subsidies that often did not cover the average cost. The end result of this approach was that neither did subsidies reach targeted consumers nor were internal resources provided to the producers who needed them to enhance supply. Also, it promoted inefficient usage among a few subsidized classes.

Figure 11 Transmission and distribution losses in Uttar Pradesh



Irrational pricing of energy is often said to be responsible for the inefficiencies that exist in the economy. The flat rate tariff (based on pump set capacity) for agriculture does not provide an incentive to farmers to manage consumption or move to more efficient appliances. In the absence of time-of-use pricing, consumers do not respond to peak or congestion situations appropriately.

Inefficient transportation tariffs are also having a significant impact on energy choices. The cross-subsidy provided by freight movement to passenger movement in the railways is ensuring that an increasingly larger share of freight demand is met through road movement which is significantly less efficient—both in energy and economic terms. Such distortions also threaten a wider range of choices as brought out in Box 5.

Energy and the environment

Excessive reliance on bioresources to bridge the gap between energy demand and supply is taking a heavy toll on the environment while the difficulties of access and the poor technology for use are having an adverse impact on the health and earnings potential of the poorer sections of the population. The excessive removal from forest areas is putting a severe stress on the country's natural resources (GoI 1997). On the other hand, burning of biomass in inefficient cookstoves is one of the major causes of chest- and lung-related health problems among rural women and children (Box 6).

The use of agricultural residue and dung as energy sources rather than as fertilizers, is impacting on the soil nutrient level. Of the total nitrogen content of dung production of 1.35 MT, 0.4 MT is lost annually through the burning of dung as fuel (Ravindranath and Hall 1995). On the other hand, only 23% of the applied chemical fertilizer reaches the plant; the balance either leaches beyond the root zone or is lost by volatilization. Overuse can severely contaminate the soil, groundwater, and the atmosphere.

The trend of continuing modal shift in favour of the roads vis-à-vis the railways and increasing private ownership of vehicles vis-à-vis public transport is also contributing to increasing levels of pollution. Reversing these trends could result in sig-

Box 5 Coal transportation versus electricity transmission

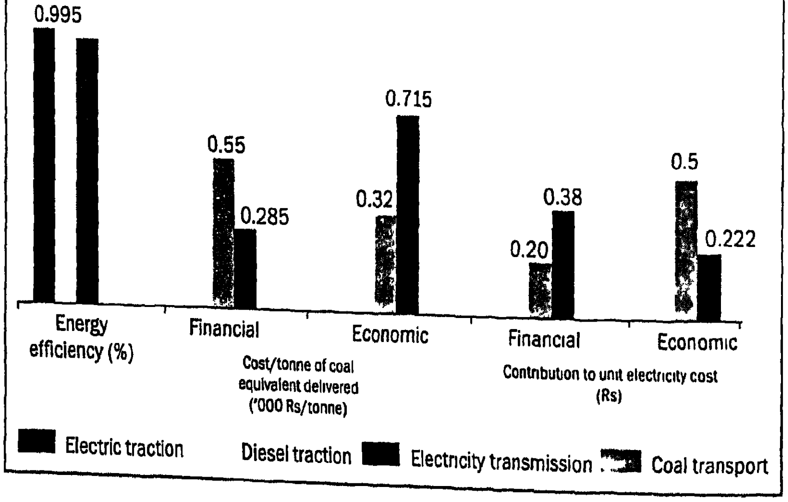
One of the choices often discussed is that of transporting coal over long distances to generate electricity at the load centre versus converting coal to electricity at a coal pithead and transmitting electricity instead. This issue becomes particularly relevant because of the high ash content of Indian coals and a perceived economic benefit in doing so.

TERI undertook an exercise (February 2002) to examine the relative benefits of providing electricity to a distribution area via these two routes.

The broad assumptions here include the following.

- Average lead distance for coal transport is 750 km and calorific value is 4000 kcal/kg.
- Transmission tariff is taken as Re 0.20/unit in financial terms and Re 0.50 in economic terms.
- Cost for coal transportation is taken as Re 0.73/tonne-km in financial terms and Re 0.42/tonne-km in economic terms.
- There are no capacity constraints for coal transportation and power transmission.

The result of this exercise is presented in the figure below. It appears that the energy efficiency (measured as energy used/unit energy delivered as electricity) of transporting coal is higher than converting coal to electricity and transmitting the same. When examined in terms of cost efficiency, transmitting electricity is cheaper when assessed in financial values. However, as well known, current transmission tariffs are lower than marginal costs whereas rail freight tariffs are higher due to the cross-subsidy provided to passenger transportation. If these tariffs are corrected, conservatively, to reflect truer costs as given in the assumptions above, then the picture reverses. Transporting coal to the demand centre for generating electricity would be more cost-efficient in addition to being energy-efficient.



Box 6 Environment and health

With its large poor, urban, and rural populations still using solid fuels in traditional devices, the indoor air pollution is likely to remain a problem in India. As per the 1991 census data, 81% of all households in India relied on unprocessed solid fuels. Such fuels are substantially more polluting than liquid and gaseous fuels. Measured levels of health damaging pollutants from biomass stoves are over 10 times higher than the standards. This leads to serious health implications such as acute respiratory infection, chronic obstructive lung disease, adverse pregnancy outcomes, and eye irritation. Children and women are the most affected sections of the population, as their levels of exposure are high. Various estimates of annual premature mortality due to indoor pollution in India are given below.

Premature mortality (per thousand) due to

Outdoor exposure	Indoor exposure	Source
50–300	850–3300	Smith (1994)
84	590	WHO (1997)
200	2000	Pachauri and Sridharan (1998)

All these estimates indicate that the disease burden due to indoor air pollution is in an order of magnitude higher than that of outdoor air pollution and place indoor air pollution as a major risk factor in the country.

nificant fuel savings as also reduced emissions. The scope for reducing annual rate of growth of diesel consumption from 5.5% to 3.7%, and that of petrol from 4.5% to 3.9% has been identified, with concomitant environmental benefits (Pachauri and Batra 2001).

Similarly, reduced demand for power (through demand-side management), improved fuel mix, superior power generation technologies, as also more efficient pollution control devices, can lead to a significant reduction of particulate matter, NO_x, and SO_2. According to TERI's projections, the impact of the measures listed above could be substantial in the next 20 years in that it would reduce the suspended particulate matter load by as much as 90% and NO_x and SO_2 to the extent of 40%, relative to the base case. Needless to say, improvement in en-

ergy efficiency of the industrial sector would have concomitant benefits for the environment.

Recent developments

More recently, however, there has been some effort on the part of the government to address some of the problems plaguing the sector. Largely driven by the recognition that energy shortages were threatening the economic growth potential of the country, the government took a serious look at measures to increase energy supply in the late 1980s and early 1990s. Given the state of public finances, it came to the conclusion that participation by the private sector was essential to address the energy bottleneck. However, in order to attract the private sector into helping build the energy infrastructure, several reform measures were identified for implementation. One of the key reforms related to the distancing of regulatory functions from those of policy making by the government. As a result, independent regulatory commissions have been established at the central level and in several states of India. Other states are being encouraged to establish such institutions with the primary functions of rationalizing tariff and encouraging competition. But their performance has been impeded due to inherent failures in grid performance, SEB operations, high T&D losses, and lack of conservation efforts in the sector.

The Ministry of Petroleum and Natural Gas has also been engaged in the process of defining a conducive regulatory structure for the last four years and an independent regulatory commission for oil and gas will be established in the near future. Moreover, with the recent dismantling of the APM (administered pricing mechanism), there has been some degree of price rationalization. Prices of transportation fuels (petrol and diesel) are now market-determined, while subsidies on LPG and kerosene are fixed in the annual Union budget.

The coal sector, too, has experimented with attracting private investments into coal mining but with limited success. While some attention is being given to the establishment of an independent regulator, unless this is accompanied by a restructuring of the public sector companies to dilute their monopolistic position it is unlikely that the private sector will respond. Also,

power sector reforms would have to precede the inflow of private sector funding in the coal industry. Also, given the role of the coal industry in providing large-scale employment, it is only to be expected that there will be considerable resistance from the unions to a restructuring of the sector. However, given the urgent needs of the energy sector, the government needs to have a clear action plan for moving ahead despite these hurdles. In the absence of such restructuring, the initiatives taken by the government - in the form of price and distribution decontrol – are not likely to yield desired results.

The passing of the Energy Conservation Act recently should provide some impetus to the drive for efficiency improvements. It may be too soon to predict the scope of impact of the Act as a whole, but some of the regulatory measures given in the Act may be ineffective due to the following reasons.

The practical experience of mandatory energy audits is not encouraging. On one hand, this has led to the mushrooming of a large number of consultants not competent enough to provide the type of services that are required to justify this opportunity. On the other hand, the managements of industrial enterprises see audits as a legal requirement and not as a tool for improving performance. The result is a routine filing of reports to meet the statutory obligation, thus defeating the basic purpose. The Act also proposes to introduce mandatory standards and norms for equipment and existing process industries. The implementation of such norms may prove difficult given the fact that a large number of such appliances are manufactured in the unorganized sector catering to the rural population, and embody different technologies and vintages of equipment.

Charting the course: an integrated energy strategy for India

To meet the energy needs of all segments of India's population in the most efficient and cost-effective manner promoting rapid economic growth while ensuring long-term sustainability

Vision

The energy challenge for India is enormous. A large population with relatively low income levels, very low per capita consumption levels, and the imperative to increase the rate of economic growth are all going to put pressure on the demand for energy. This pressure is building up on a system that is already under critical strain, functioning in a situation of shortages. With major economic reforms under way, and a new global order being put in place, TERI feels that this is an opportune time for India to take a longer-term view of economic imperatives and chart a course that would move away from pure crisis management to providing a strategic direction to energy development. Given the magnitude of the challenge in meeting energy demands in a sustainable manner, India needs to look at all possible ways of bridging the energy gap.

Matching the criteria for moving along a sustainable energy path with key issues and challenges identified above provides the direction in which policies need to be oriented in the future.

What emerges starkly is the fact that the set of policies requiring reorientation transcend the allocation of responsibilities given to specific ministries. Some examples of this will become apparent in the next few paragraphs as the goals and strategies of an integrated strategy for energy are outlined.

Provide clean and affordable energy to all

As pointed out earlier, a large percentage of the poor in India, both in rural and urban areas, do not have access to energy markets and/or cannot afford energy purchases. Over 50% of the population continues to be deprived of commercially-oriented energy forms. The equity dimension of a sustainable energy path requires that this challenge be addressed urgently.

The first step, to facilitate the access to energy by the poor, would require the existence of appropriate and efficient energy delivery mechanisms. There is a notable absence of formal market structures in rural areas for alternative energy options, i.e., commercial fuels and renewable technologies. Market intermediaries (distributors, dealers, and retailers), facilitators (credit offering agencies and service companies [repair and maintenance]), and local participation are all necessary for ensuring widespread and effective distribution of products/ services. Rural areas lack such institutional structures. The fact that rural markets are more dispersed than urban agglomerations makes the task even more difficult.

The other major challenge would be making energy affordable to the poor. The typical approach that was being adopted was one of providing subsidies. There is enough evidence over the last several decades to realize that such subsidies are not reaching the target populations. Box 7 sets out an example by which subsidies could be used more effectively.

Subsidies are also not the most efficient way of making energy affordable. While the government is attempting to put in place a targeted public distribution system, it is recommended that this targeted population be identified using very stringent criteria. For the balance of the poor, the government's effort should be directed towards facilitation rather than dole. For this purpose, India needs to start looking at a different set of mechanisms. The poor need to be able to choose from a

Box 7 Subsidy on kerosene versus solar lanterns

The huge subsidy given on kerosene for rural lighting, amounting to Rs 32 760 million annually, is a considerable drain on the country's economy. Promoting a switch to alternative lighting options from kerosene can constitute significant savings. One such option is promoting the use of the environment-friendly solar lanterns. The kerosene consumption replaced by the use of solar lanterns will result in an estimated savings of Rs 26 758 million annually on subsidy to kerosene. The savings on the subsidy for kerosene can be used to subsidize solar lanterns to the extent of 50%. The balance 50% would be the contribution of the consumers towards the cost of the solar lantern. This could be facilitated through the provision of credit facilities. The annual cost to the consumers of this credit can be designed to be no more than their actual expenditure on kerosene purchased and can be repayable in three years. It is estimated that in this manner, about 20% of the targeted households can be covered annually. Hence in a period of five years, all the households using kerosene as the primary fuel for lighting can be covered. The avoided expenditure on kerosene would be more than sufficient to cover the repair and maintenance cost of the lanterns disseminated. This step will also facilitate setting up of rural enterprises based on provision of repair and maintenance facilities for the solar lighting systems.

Source TERI analysis

specially designed set of services tailored to meet their end-use needs in quantities that they can afford. The rural energy entrepreneurs would also have to be organized to provide this entire set of services rather than having separate set-ups for electricity, LPG, kerosene, renewable technologies, etc. A one-stop shop concept has to be evaluated. The subsidies thus saved should be directed towards facilitating the design of appropriate credit mechanisms that would again be tailored to the income patterns of the poor.

The Ministry of Non-conventional Energy Sources should be transferred to function under the Minister of Power, and the functions of the Rural Electrification Corporation should be merged with the Commission for Additional Sources of Energy. The merged organization should implement its programmes for rural energization solely through NGOs, educational and research institutions, cooperatives, and community-based

organizations. State nodal agencies for renewable energy should be drastically downsized and should no longer implement programmes directly, but instead function through the types of agencies mentioned.

A novel concept currently under testing is the 'Uttam Urja' model, initiated by TERI and the India-Canada Environment Facility (Box 8).

Box 8 Towards an energy service network, the 'Uttam Urja' model: promoting self-sufficiency

In the Uttam Urja model, the 'household lighting package' is sold through local enterprises under the brand name 'Uttam Urja'. The customer pays a basic upfront cost and then the equated instalments for a specified period after which the ownership of the device is transferred to her/him. During this period, major maintenance costs, such as replacement of battery and printed circuit board, are borne by the service provider.

Agencies at the local level like non-governmental organizations and rural retailers/dealers form an ESN (energy service network), which works towards implementing a model wherein the renewable energy technology users are treated as 'consumers' of the 'service' that the ESN provides and pay for it at regular intervals. Part of these payments is the collection charge for the service-providing agencies, part goes towards meeting the maintenance costs, and the balance is deposited as a revolving fund for further replication.

Payments can be made quarterly or bi-annually depending on the convenience of the customers. The objective of this approach is to free the consumer from problems of high upfront costs, maintenance, replacement, etc., which have been responsible for limited penetration and impact of RETs in rural areas.

Source TERI (2001)

Policy coordination across energy ministries and ministries of rural development, finance, environment and forests, and agriculture

Ensure security of energy supply

The adverse implications of increasing oil and coal imports for energy security necessitate not only an integrated assessment of options for enhanced productivity and efficiency in the energy sector, but also a determination of the optimal mix of these energy imports. At present, each sector meets its shortfall by importing required amounts. The resultant energy mix, devised from such a disaggregated approach, may not be efficient or optimal from the point of view of the entire sector or the economy. Cost savings and environmental benefits could accrue if options for energy substitution and hydro imports from neighbouring countries like Nepal and Bhutan were examined in an integrated manner.

Achieving an optimal fuel mix for the country requires a careful evaluation of indigenous resources, scope for energy conservation as also inter-fuel substitution, and environmental concerns. This necessitates the development of a comprehensive database on all energy resources—including renewable and nuclear energy; technologies to produce, transport and consume energy; relative economics at every stage of the energy cycle; as also the environmental costs. Pricing and investment policies should take cognizance of the trade-offs involved in following alternative energy paths. An evaluation of these trade-offs should be undertaken by adapting existing integrated assessment models and other sophisticated techniques that are constantly being upgraded.

Of particular importance is the need to develop a technology plan that will exploit newer energy forms (e.g. CBM, gas hydrates) and energy efficient/zero-energy (e.g. biofertilizers) ways of meeting specific end-use demands. India needs to have a much more significant R&D programme that would encourage privately based research and reward innovations appropriately. R&D efforts based on public resources should largely be directed towards reducing the costs of energy delivery to the poor. Any larger R&D programmes undertaken by publicly funded research institutions must necessarily be commercially driven.

Energy security concerns also arise from domestic situations such as the Gujarat earthquake (2001) or the super-cyclone in

Orissa (1999). Each state in the country should have an emergency energy plan that would clearly identify strategies by which the human impacts of such disruptions can be mitigated.

Policy coordination across energy ministries and ministries of external affairs, commerce, home, science and technology, and environment and forests

Improve the efficiency of the energy system

Exploiting the potential for energy efficiency improvements will enhance the longevity of energy resources while reducing the cost of delivering energy and protecting the environment. The Ninth Plan document emphasized that the *actual realization of this potential will depend on policies including pricing both for energy products as well as for end-use equipment/devices and on institutional changes that take place in the energy sector.*

As recent developments indicate, some of the key institutional changes that are being brought about include the promotion of competition in most energy sub-sectors as well as a move to market-determined pricing. However, as also brought out in the paragraph pertaining to developments in the coal sector, the lack of a holistic approach is negating the potential benefits of such reforms. The power sector too is suffering from the lack of progress in coal reforms while coal movement suffers from the lack of tariff rationalization in the railways. There is, therefore, a need for a coordinated movement across all sectors linked to the provision of energy services.

The experience after the institution of independent regulatory commissions reveals that the credibility of these institutions is being eroded rapidly due to the shackles placed on them in terms of the expertise of staff that they can attract, the procedures for selection of commission members, and the continued conflict of interest that governments are displaying vis-à-vis public sector companies. It is imperative that the regulatory commissions must have, and must be seen to have, the capacity to go about their business effectively.

In this context, it is important also to corporatize the public sector companies and allow them to operate on commercial

principles as that would not only facilitate competition but also ensure their own competitiveness.

The other major factor affecting efficiency, recognized by the Ninth Plan document, is that of energy pricing. Prices have been decontrolled in the case of coal (albeit in a continuing monopolistic regime). In the case of electricity, the approach adopted is a mixed one. Historical costs are being pooled with marginal costs to arrive at an average cost of electricity that is then converted into tariffs recognizing the need to avoid tariff shocks and to continue with some cross-subsidies. Most prices continue to ignore the costs imposed on the environment! While petroleum product pricing has been decontrolled, the government continues to dictate price lines to oil companies. Such a mixed approach is obviously not conducive to promoting either an efficient allocation of resources or to promoting competition. Reference is made to alternative methods of facilitating access to energy in the previous section. India needs to go further and de-link the social function of subsidy provision from energy pricing decisions. Subsidies, if any, should be delivered in a completely transparent manner.

However, the government should play a facilitative role towards sensitizing various stakeholders to the efficient options available and the benefits of energy efficiency. For instance, efficiencies in the transport sector can be substantially enhanced through rational pricing to reverse the shift from rail to road movement. Unconventional approaches to energy efficiency also need to be integrated into an overall strategy. For example, a movement towards precision agricultural practices can substantially reduce the energy demands from the agricultural sector. Better water management and rainwater harvesting can also contribute towards the end objective of reducing energy demand for irrigation purposes. Urban traffic management measures have also been discussed incessantly but in the context of congestion planning and environmental impacts. The energy demand reduction implications of these measures also need to be emphasized.

Policy coordination across energy ministries and ministries of disinvestment, finance, water resources, urban development, and law

Reduce the adverse environmental impacts of energy production and use

The costs of environmental damage when measured in terms of loss in potential GDP have been estimated to be in excess of 10% (Pachauri and Sridharan 1997). The poor are, once again, most vulnerable to the adverse impacts of environmental damage and have the least adaptive capacity. The energy sector has a major impact on the environment and on human health as indicated in earlier sections. If this issue has to be adequately addressed, a comprehensive database on energy–environment interactions, emissions, and costs needs to be undertaken. Internationally, several new techniques have been developed that allow an integrated assessment of environmental impacts including the costs and benefits of environmental changes.

One of the major knowledge gaps that hinders an internalization of environmental costs on account of energy production and use is the ability to isolate the impacts from specific sources—in this case energy and related activities. In the absence of such internalization, energy pricing will always demonstrate distortions and inequities that may be politically unacceptable. The city of Delhi has witnessed the debate on the introduction of clean automotive fuels—the war between CNG and ultra-low sulphur diesel. This debate has been taking place in the absence of complete knowledge on impacts – both environmental and social – and the distribution of such impacts.

One argument that can be put forward is that the move to market-determined pricing of energy, if accompanied by a strict enforcement of environmental standards, would take care of such concerns to a large extent. However, as international experience shows, certain environmental costs would have to be explicitly addressed. Examples of such environmental costs include taxes on emissions of GHGs such as CO_2.

The country must, undoubtedly, move to an accelerated adoption of environmentally-friendly energy technologies. Apart from developing the knowledge base required to determine priority interventions, India also needs to strategically exploit opportunities arising out of international agreements such as climate change to meet energy goals. The CDM (clean development mechanism) under the Kyoto Protocol is an

example of such an opportunity. It also needs to be recognized that international environmental concerns will place pressure on India to reduce its coal consumption, thereby placing a higher premium on issues such as energy security.

Policy coordination across energy ministries, ministries of environment and forests and commerce, and the Planning Commission

In sum

Integrating energy strategies for a country is not about numbers and predetermined targets. In its most effective form, it is the establishment of institutional links, coordinating mechanisms, market forces, and the incorporation of social or security goals in its formulation and review. To that extent, the sub-sectoral reforms taking place, for instance, in the power and hydrocarbon industries, are in the right direction. But these need to be accelerated and coordinated as explained above.

Another aspect of integrated energy strategy, which would be crucial to the national interest in the future, is its linkages with foreign policy. TERI has been promoting for over a decade the importance of natural gas imports from Iran (through Pakistan) on the west and Bangladesh and Myanmar on the east. Additionally, the huge resources of oil and gas in the republics of Central Asia make this region extremely important to India for this reason alone, quite apart from trade and economic cooperation in other fields. In the renewable energy field, it is important for India to build up its technological capabilities for domestic reasons as well as to exploit the comparative advantage we would have in tapping markets in other countries.

Effective coordination and monitoring of an integrated energy strategy should be performed by a cabinet committee specifically for this purpose to be chaired by the Prime Minister. The analysis and technical support essential for the functioning of this committee should be provided by an expert organization outside the government channelled through the cabinet secretariat. For this purpose, the PMO (Prime Minister's Office) or cabinet secretariat should be staffed by a Joint Secretary, against a post that may be transferred from one of

the line ministries. Additionally, the PMO may revive the National Environmental Council established during the Prime Ministership of Mr P V Narasimha Rao, and this may be redesignated as the National Energy–Environment Council. This body should then become the forum for discussion and debate on energy–environment policies for the country and changes that need to brought about from time to time.

Energy is much too important a sector to be dealt with in a fragmented manner within the government. The price for uncoordinated and unfocused action would be (1) a high-cost energy system for the country eroding India's competitive edge in a globalized economy, (2) continuing deprivation and fuel scarcity for a large part of our population, (3) serious environmental problems with adverse health implications, and (4) growing uncertainty regarding security of energy supply. There is, thus, urgency in bringing in institutional changes for development of an integrated energy strategy. This document attempts to initiate a debate to bring about such an outcome through the involvement of major stakeholders in Indian society.

References

AITD (Asian Institute of Transport Development). 2000
Technology change: slow and unsteady
The Asian Journal 7(2): 44–51

CEA (Central Electricity Authority). 2001
Executive Summary: Monthly Review of Power Sector Performance, October 2001
New Delhi: CEA

CEA (Central Electricity Authority). 2002
Actual Peak Demand Vs Peak Met
New Delhi: CEA
[Available at <http://www.cea.nic.in/data/opt2_peakdemand.htm> last accessed on]

CMPDI (Central Mine Planning and Design Institute). 2001
Millennium Coal Vision
Ranchi: CMPDI
[Output of the National Seminar on Coal, Ranchi, 20–21 December 2001, organized by CMPDI]

DGH (Directorate General of Hydrocarbons). 1999
Petroleum Exploration and Production Activities in India
New Delhi: DGH

GoI (Government of India). 1997
Ninth Five-Year Plan: 1997–2002
Vol. II: Thematic issues and sectoral programmes
New Delhi: Planning Commission, GoI. 1059 pp.

GoI (Government of India). 2001
Report of Working Group on Coal and Lignite for the Tenth Five-Year Plan (2002–07)
New Delhi: Ministry of Coal, GoI

Hydrocarbon Asia. 2001
Cross border 'win–win' scenario in Indian subcontinent
Hydrocarbon Asia, September 2001, p. 42
[Available at <www.hcasia.safan.com> last accessed on 7 February 2002]

MNES (Ministry of Non-conventional Energy Sources). 2001
Annual Report 2000/01
New Delhi: MNES, Government of India

NSSO (National Sample Survey Organization). 2001a
***National Sample Survey 55th Round* (July 1999–June 2000)**
New Delhi: NSSO, Ministry of Statistics and Programme Implementation, Government of India

NSSO (National Sample Survey Organization). 2001b
***Energy Used by Indian Households* (1999–2000)**
New Delhi: NSSO, Ministry of Statistics and Programme Implementation, Government of India [Report No. 464]

Pachauri R K and Batra R K (eds). 2001
DISHA (Directions Innovations and Strategies for Harnessing Action) for Sustainable Development
New Delhi: TERI

Pachauri R K and Sridharan P V (eds). 1998
Looking Back to Think Ahead
New Delhi: TERI. 346 pp.

Planning Commission. 2000
Mid-Term Appraisal of the Ninth Five-Year Plan (1997–2002)
New Delhi: Planning Commission, Government of India
[Available at <planningcommission.nic.in/midf.htm> last accessed on 7 February 2002]

Ravindranath N H and Hall D O. 1995
Biomass, Energy, and Environment: developing country perspective from India
Oxford: Oxford University Press

Smith K R. 1994
Paper presented in the Workshop on the Energy-Environment Nexus: Indian issues and global impacts
Pennsylvania: Center for the Advanced Study of India, University of Pennsylvania, Philadelphia

TERI (Tata Energy Research Institute). 1996
Rural energy sector in India
New Delhi: TERI
[Report submitted to The Royal Danish Embassy, New Delhi]

TERI (Tata Energy Research Institute). 2000
TERI Energy Data Directory & Yearbook 2000/2001
New Delhi: TERI. 452 pp.

TERI (Tata Energy Research Institute). 2001
Towards an energy service network, the 'Uttam Urja' model: promoting self-sufficiency
INSTEP: with business opportunity 1: 13–14
New Delhi: TERI

The World Bank. 1991
Long-Term Issues in the Power Sector in India, Asia Region, p.154
Washington, DC: The World Bank

The World Bank. 2002
World Development Indicators 2002
Washington, DC: Oxford University Press

The World Bank Group. 2001
Indoor Air Pollution
Energy and Health for the Poor 4
Washington, DC: The World Bank

WHO (World Health Organization). 1997
Health and Environment in Sustainable Development
Geneva: WHO